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# Impact of Technological Change of Large-Scale Organizations

Dr. Charles E. Hutchinson, Behavorial Sciences Division, AFOSR

This is a changing world. A large aircraft company is wondering what to do with the bright, highly-trained, young engineers whom they encouraged to take postgraduate work in aeronautical engineering, now that the corporation has moved out of aircraft and into space activities. Similar shifts occur in the military establishment at frequent intervals. To cope with the effects of changing technology on military organizations, AFOSR is supporting the research of Dr. Raymond V. Bowers of the Social Science Research Institute, at the University of Georgia.

The military services are aware of the overwhelming effects of science and technology on the development of weapons. The weapon system concept was invented to deal with the conceptualization, advanced planning, design, prototype construction, testing, and development of new weapons. The concept was a non-material invention that permitted the military to come to grips with some major problems in the development of successive families of new military devices. Concurrent with the development of physical systems, new TOE's, job specialties, training materials, and training procedures are designed and organized to provide for the manning of new equipment. In short, each new major weapon system which becomes operational involves the design of new military organizational elements to support, operate and command the new weapons. Up to now, there has been a hierarchial order of preference in system development studies. Most attention has been directed to the development of the physical science and engineering aspects of the newly conceived weapons. Belatedly, designers of systems are becoming concerned about the way in which operators and managers function as

parts of systems. Very little serious attention has been paid to the organizational factors which affect the efficiency of military and non-military operations.

In some well known instances, a modest amount of attention to the situational and organizational aspects of performance have paid off handsomely. Two studies, one industrial and one military, are widely recognized as examples of the potential payoff from attention to organizational and interactional variables.

In an industrial setting, the research of Elton Mayo and associates, conducted in the Hawthorne Plant of the Western Electric Company, more than a quarter of a century ago, is still recognized as a breakthrough in understanding the importance of organizational behavior. The investigators found, in brief, that the interactional influences on worker output were more potent than any or all of the other factors that were manipulated during the course of an extensive five-year study.

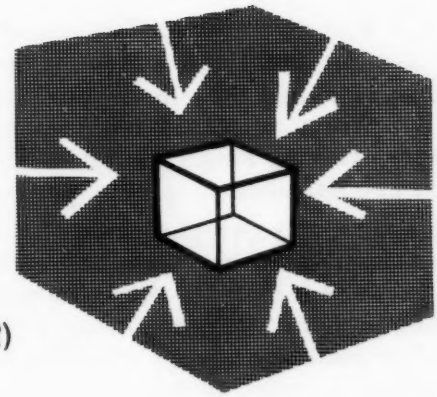
The Air Defense Studies of Dr. John Kennedy, performed while he was employed by the RAND Corporation, indicated the primacy of organizational factors in the effectiveness of military operations. Kennedy and his associate, Robert L. Chapman, demonstrated the effectiveness of group interaction, performance feedback, and the evocative leadership in multiplying the effectiveness of air defense man-machine systems. The accomplishment of the Kennedy-Chapman studies is attested by the creation of a new company, the Systems Development Corporation, to develop, refine, and disseminate to operational commands, the best available information regarding organized behavior in a system context.

Despite notable research accomplishments in military and civilian environments, fundamental research on the effectiveness of large-scale organizations has been given only minimal support by the military services. For this reason, the work directed by Dr. Raymond V. Bowers at the Social Science Research Institute, of the University of Georgia, can be considered a pioneering venture. The most recently completed study in the program on the effect of technological change on the careers of executives in industry and in the military is reported by Stanley Greenspon, in an article entitled: "The Impact of Technological Change on the Structure and Function of Large-Scale Organizations."

Greenspon utilized a working model of large-scale organizations drawn from the "rational" model of the theoretical Max Weber, and a "natural system" model, which has received contributions from many empirical workers. The model focuses on four organizational components: (1) *organizational goals;* (2) *the formal organization;* (3) *the informal organization;* and (4) *the reward system* (positive and negative sanctions); as essential for the analysis of any large-scale organization.

The author of the report utilizes this framework for the reanalysis of the findings of the small number of available scientifically adequate case analyses of organizations which have been subject to radical organizational change, due to technological innovation, or administrative reorientation. This limited survey confirms the findings of previous field studies that innovations have very significant effects on organizational functions. The report goes beyond this in an attempt to point out the nature, direction, and magnitude of organizational response in the various categories of the model. Further research and analysis of original data will be necessary to test the predictive efficacy of the model. However, the preliminary report does offer the promise that it is possible to develop a predictive model which would forecast the effects on organizations of innovations, due to technological advances. Such a model should make it possible to design or adapt organizations to meet the demands created by the regular succession of advanced weapon systems.

# 20,000,000 POUNDS PER SQUARE INCH



Dr. Amos G. Horney
Directorate of Chemical Sciences (AFOSR)

Hammering, stamping, forging and other pressure techniques have been used for centuries to force matter into desired physical forms. But can pressure change the chemical nature of materials, can it create not only new shapes for old materials but can it create new materials? The effects on chemical equilibria (ammonia synthesis, etc.) are well known and important, but what about the chemical effects on simple substances by straightforward, massive, hydrostatic pressure -- say 20 million pounds per square inch? Thermonuclear devices generate pressures many orders of magnitude greater than those that can be generated with ingenious and massive apparatus such as that pioneered by P. W. Bridgman

What happens when a substance is subjected to pressure high enough to overcome chemical bonds and the atoms are forced to interpenetrate? Nobel Laureate W. F. Libby, whose carbon dating as well as his current researches were and are supported by AFOSR, believes that he has at least a partial answer to this question. He believes that under extremely high pressure (say 1,000,000 atm.) atoms can be forced together so that their electron shells coalesce. In this highly compressed state perhaps only a few electrons can be considered localized on each atom, the other electrons of each atom being associated with the entire solid mass. Upon acquiring this state any substance may then be considered as a metal, having closely packed atomic cores and "conduction" electrons. This is certainly an interesting and reasonable picture, but at first sight it seems to be extremely difficult to substantiate. Direct observation of the properties of matter under such pressures is a formidable task.

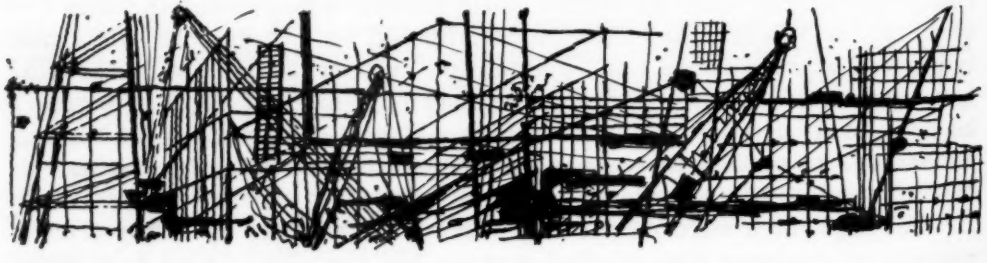
An ingenious support for this theory is provided by Libby from reports of workers who studied meteorites containing a certain form

of graphite. The geometric structure of this form of graphite is related to that of diamond. One might expect that under compression both assume identical, close-packed structures and when the pressure is released the close-packed form expands to the most dense stable form - in this case, diamond. Several investigators have reported finding small diamonds in graphite embedded in meteorites which are believed to have experienced high pressures for short times. This apparently demonstrates that the graphite had been forced by pressure to assume the close-packed, metallic form from which diamond was produced. It also might be theorized that diamond could have been formed by bond rearrangement without the formation of an intermediate metallic state; however, there is evidence that the rate of diamond formation is much faster than expected without the postulate of the "metallic" intermediate.

An analogous effect is demonstrated by Libby in an egg-cooking experiment. The structure of egg protein is largely determined by hydrogen bonds. These bonds are among the first to be distributed when hydrostatic pressure is applied to protein. It is believed that the pressure forces the molecules together so that the molecules involved in hydrogen bonding have a more or less metallic aspect, (delocalized electrons). On expansion there is small chance that the molecule will revert to its original form but is more likely that different H-bonds will form -- that is, that the protein will be denatured and thus the egg will be "cooked."

Recently at the National Academy of Sciences, Dr. Libby showed colored slides of a varied group of protein-containing substances cooked -- instantaneously -- by pressure in the cold. Steak, eggs and vegetables are all palatable after this treatment.

At present the use of ultra-high pressures is an interesting laboratory curiosity just as ultra-high vacuum effects were some years ago; in the future ultra-high pressure chemistry promises to be as valuable a synthetic tool as ultra-high vacuum is today.



# A PSYCHOLOGY FOR COMPUTERS

Dr. Harold Wooster, Directorate of Information Sciences (AFOSR)

Many years ago, say from 1750 to 1900, when "psychology" was very young, psychologists used to try to find out how other peoples' minds worked by introspection -- by looking inward to their minds. They found that something always reminded them of something else. This was called "association of ideas" and many words were written and many elaborate theories developed to explain all thought processes in terms of mechanistic forces acting on discrete entities called "sensations", "images", and "ideas".

"Association psychology" is now regarded as an academic curiosity, and the psychologists have gone on to study the behavior of other entities, behavior that can be quantified and verified with all the nice tools of the experimental sciences, rather than trying to convince others of their own thought processes.

Computer experts, in studying the possible mechanization of thought processes, do tend to rush in where psychologists no longer tread. One such, Richard Reiss of Librascope Corporation under contract AF 49(638)1039, monitored by the Information Research Division, AFOSR, had the idea of trying to state the tenets of association theory in computer terms, to show what a computer system based on association theory might look like and how it would act, and to see if the formal description of such a machine would give useful ideas and insights.

The results of his preliminary study are set forth in a paper, "An Abstract Machine Based on Classical Association Psychology",

presented at the recent Spring Joint Computer Conference in San Francisco, 1-3 May 1962.

Reiss' approach has been through the assumption of postulates of increasing complexity, and the examination of these postulates on the basis of: "How would a machine based on these postulates perform?"

The first four postulates form a group which produces a basic machine without sensory inputs or motor outputs, a machine which ceaselessly processes the same store of information. These postulates are: (1) That there is a finite set of "memory tokens"; (2) That each pair of tokens is linked by two bonds, with strengths measured by "coupling coefficients"; (3) That there is an attention register which can hold a small portion (one or more) of the total store of tokens; and, (4) That at intervals a token is chosen at random from those already coupled to the tokens in the attention register. If the register is filled, the "oldest resident" token is simultaneously ejected and returned to the store.

The sequencing of memory tokens through the attention register might be interpreted as the first crude approximation to the flux of ideas, images, etc., into and out of the conscious state. Reiss goes on to examine the consequences of these postulates, exploring the different ways in which the tokens can be bonded (strings, rings, chains and trees) and the conjoined effects of varying these coupling patterns and the length of the attention register. With these variables he finds it possible to create (in the sense of formal statement) either stochastic (governed by chance) or deterministic machines, to examine the effects of attention span, to produce an effect similar to the "remote forward association" of serial learning experiments, and even to show that there is no necessary conflict between association theory and gestalt phenomena.

Reiss introduces his next two postulates to state the "laws" of "Similarity" (cat reminds you of rat because the names look or sound alike) and "Contiguity" (girls remind you of coffee because you see them in the snack bar). These laws are stated formally as: (5) Every coupling coefficient is the sum of an "external coefficient" and an "internal coefficient"; and, (6) The external coefficients start off with a zero value, which is increased every time two tokens appear together in the attention register. The internal coefficient values remain constant for all time.

Postualtes (5) and (6) allow the external matrix to reflect the "experience" of the machine, that is, its past behavior in sequencing memory tokens through the attention register. The internal bonds represent the degree of "similarity" in the internal "structures" of the two tokens involved.

One consequence of the two additional postulates is Reiss' demonstration that, as the machine operates by passing tokens through its attention register, the external bonds grow and the machine becomes more deterministic, tending towards cyclic, stereotyped behavior patterns with few if any random fluctuations. This same strengthening of external bonds corresponds to the "frequency" laws (the more frequently girls and coffee appear together, the more one reminds you of the other).

So far, the machine has been constructed from the inside with no contact with its environment corresponding, perhaps, to Locke's "tabula rasa" ---the blank tablet on which sensory inputs write their record. The next group of postulates finally puts the abstract machine in connection with its environment: (7) There is a sensory register which at all times contains a set of sensory tokens; and, (8) At any moment, each sensory token is bonded to each memory token with a strength given by the "discrimination coefficient". Each sensory token also has a "vivacity coefficient".

Before introducing the next, and last, postulate, it is necessary to define an admission function, with a value that is, for any given sensory token, the sum of discrimination coefficients between the sensory token and all memory tokens in the attention register added to the "vivacity coefficient" of the sensory token. The admission set is composed of those tokens whose admission values are above the admission threshold. This gives the postulate: (9) At intervals, a sensory token is chosen at random from the admission set and entered into the attention register, causing the oldest memory token to be ejected from the attention register. As the sensory token enters the attention register it becomes a memory token.

This machine cannot influence the appearance of sensory tokens. Its only control over the ejection of these tokens is by admitting them to the attention register where they become memory tokens, i.e., permanent parts of the machine. The discrimination tokens represent bonds between the sensory tokens and the memory tokens. They

represent relations between the structures of tokens, not past experience, and are thus similar to the internal coefficients previously introduced. As such, they are the first approximation to the effects of a pattern recognition process, a measure of the "similarity" between sensory and memory tokens. The "vivacity coefficients" represent a word borrowed from the associationists, who assumed that the "vivacity" of a sensation or percept is a function of stimulus intensity and other factors, such as object field contrasts.

The addition of the last three postulates gives us two "registers" side by side, with a procession of sensory tokens through one and memory tokens through the other. There may be periodic transfers from the sensory register to the attention register so that the sensory procession may influence the attention procession, but not vice versa.

The introduction of sensory inputs yields a machine which grows with the passage of time. It is not "preprogrammed" in the usual sense, having just two "registers", the ability to create permanent memory tokens from transient sensory inputs, and two kinds of coupling between tokens -- one that suggests physical links (external bonds) and one that suggests the existence of a pattern recognition apparatus or "resonance" phenomenon (internal bonds).

Two points must be emphasized. The nine-postulate machine is by no means a complete nor unique explanation of classical association psychology. For one thing, the analysis of the abstract machine's behavior has been based on small groups of tokens; association theories were intended to explain the behavior of the human mind -- a very large collection of objects. Small scale analysis can only suggest general conclusions as to the large group effects when large numbers of memory tokens -- say $10^5$ to $10^7$ -- have been accumulated and are interacting with each other and with environmental inputs and outputs. Whether or not the complex combinatorial problems that arise when even a reasonably complete machine has grown beyond several hundred tokens can be successfully attacked by conventional mathematical methods remains an open question. The abstract machine has been constructed in such a way that it can be simulated -- though the cost for very large numbers of tokens might be forbidding -- on a general-purpose digital computer.

If one is to extend the abstract machine much beyond the explicit and implicit functions of classical association theory, the nine-postulate machine constitutes only the barest beginning. New sorts of sensory registers, of attention registers, and of coupling between

the tokens and the systems must be formulated.

Abstract machines of the sort postulated here do provide a means for exploring the logical consequences of the axioms of the associationist psychologists -- axioms and assumptions more usually characterized by vagueness and variation from one author to another, and a certain preference for leaving a loophole through which free-will could be slipped in if the theory should become too successful.

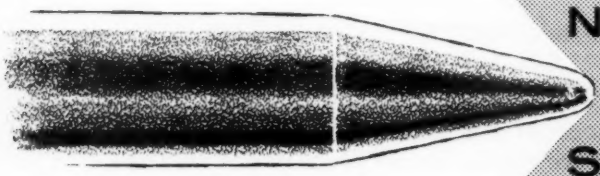
More importantly, the abstract machine as outlined by Reiss represents a fresh new approach to the building of an "intelligent machine" -- one perhaps with a possible level of intelligence comparable to the lower vertebrates.

One should not be misled by the consistent use of the word, "machine", in this article to imagine that the abstract machine is a tangible piece of working machinery. It is no more than the blueprint, flow-chart, or preliminary sketch, from which such a machine could be built. As Reiss points out:

"The forces operating in the machine, as represented primarily by external, internal and discrimination coefficients, are few but by no means simple in their physical implications. They have been assumed without regard to the difficulty of physically realizing them in any real machine (although, again, they can be simulated by brute force methods). The objective is to explore the logical consequences and promises-- if any -- of associational mechanisms. If they are sufficiently promising, attention can then be directed to the problems of physical realization."

Frank Rosenblatt's Perceptron started in just such a way some six years ago, with a set of assumptions involving association and sensory units and attempts to state the phenomena of vision on a logical, formal basis. These assumptions and their logical consequences were tested, first in the form of a computer program and then, as electronic technology progressed to the point where actual association and sensory units could be made, to tin-bending and building of actual hardware.

Reiss' abstract machine might be said to stand where the Perceptron stood some six years ago. It would be unfair to call it even an unborn babe, but it at least represents the gleam in the prospective father's eye as he heads towards Niagara Falls.



# NOSE AND INLET SHAPES OF MINIMUM DRAG IN SUPERSONIC FLOW

John V. Armitage, Major, USAF Applied Mathematics Research Laboratory (ARL)

The determination of nose shapes of minimum drag in supersonic flow is important in the design of fuselages for supersonic aircraft. The problem has a long history. It was first attacked by von Karman in 1936 on the basis of a linearization of the flow equations; a number of subsequent papers deal with the same problem on essentially the same basis.

Because the equations which describe compressible flow are extremely complex, it is almost hopeless to attack the problem without introducing simplifications. However, for one problem of this kind, namely, the forepart which has minimum pressure drag for a given length and maximum cross section, a formulation can be found where the exact flow equations enter in the form of a characteristic condition only, i. e., in the form of an ordinary differential equation. Then a formulation of the exact problem becomes possible.

A new impetus to the solution of the axi-symmetric problem came from a related problem, viz., that of a supersonic thrust nozzle that gives maximum thrust for a given length and outside diameter. This problem was treated by Hantsch and Guderley in 1945 and led to a system of differential equations which were solved by numerical methods. Later Rao found that for the special boundary conditions that apply to this problem, the equations are solvable in closed form with remarkable simplifications. This approach was extended to non-isentropic flow by Guderley in 1959. On this basis it appeared possible to bring the problem of the axi-symmetric nose shapes of minimum drag into tractable form.

ARL Technical Report 62-342 by Guderley, Armitage, and Valentine attacks the problem in full generality. By making a suitable choice of the control surface for mass flow and momentum, a

complicated system of differential equations is reduced to tolerable size by introducing a modification of Rao's method. The particular solutions thus obtained satisfy the boundary conditions nearly perfectly. A modification is made to take into account that the desired axisymmetric body shape at supersonic speeds should have a blunt nose for minimum drag. Figures 1 and 2 show the resulting inlet and closed body contours, respectively.

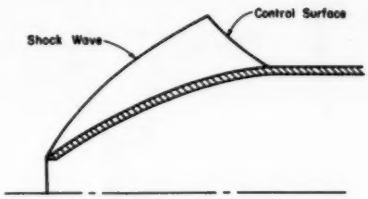



Fig. 1 Basic configuration for the inlet problem.

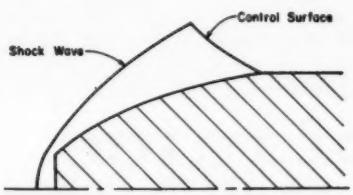



Fig. 2 Basic configuration for the closed body.

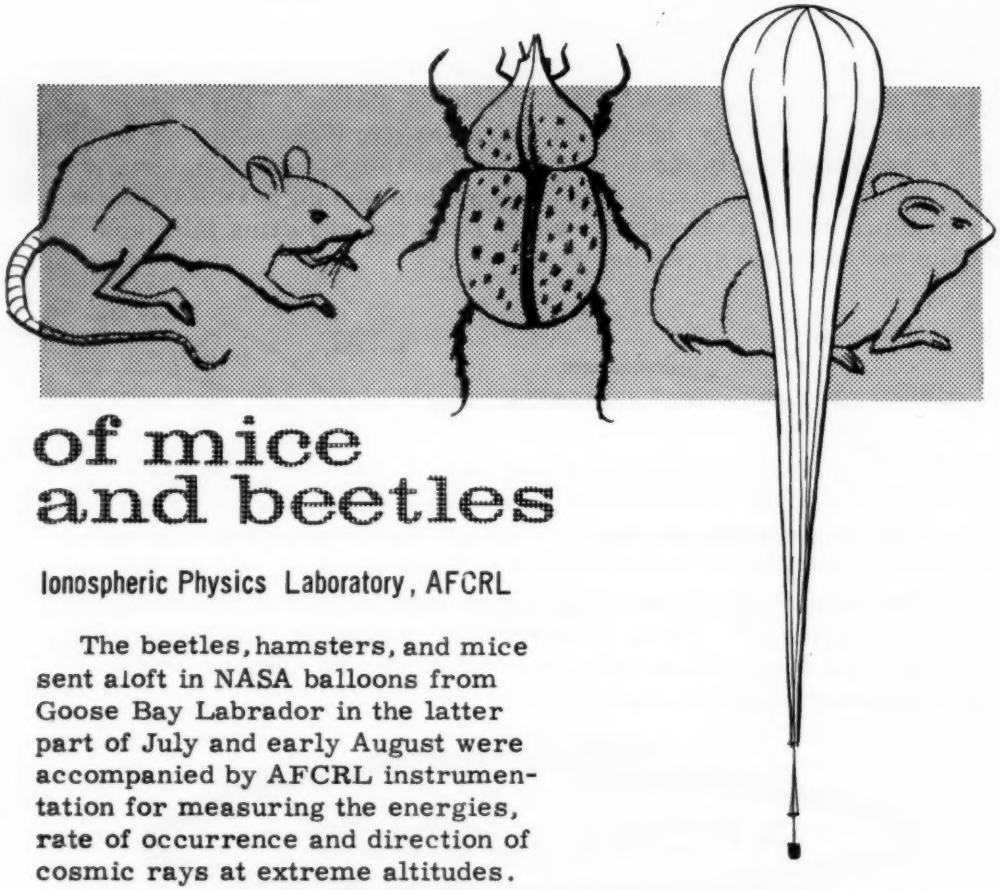
The report should find numerous applications in the design of supersonic aircraft. From a theoretical viewpoint, it is one of the few examples where an extremely complicated non-linear problem has been solved nearly exactly.

## AFCRL *Notes*

Approximately 60 AFCRL personnel are directly engaged, or have been engaged in the recent past, in experiments associated with the current series of nuclear tests in the Pacific. Data in a large number of distinct research areas are being recorded.

AFCRL, in a cooperative effort with the University of Manchester and Lockheed, participated in observations of the partial eclipse of the sun which was viewed from the Dakar area of North Africa on July 31. Equipment used was supplied by the University of Manchester, transport of equipment was arranged for by AFCRL, and Lockheed manned the temporary observation site.

AFCRL will analyze the data, from which it is hoped more precise information on the shape of the moon can be gained. A similar site was manned by Russian scientists in the same area. (Research Instrumentation Laboratory)



# of mice and beetles

Ionospheric Physics Laboratory, AFCRL

**The beetles, hamsters, and mice sent aloft in NASA balloons from Goose Bay Labrador in the latter part of July and early August were accompanied by AFCRL instrumentation for measuring the energies, rate of occurrence and direction of cosmic rays at extreme altitudes.**

Lt. Col. John Ely of AFCRL designed and built many of the equipments, and participated in the launchings at Goose Bay. The balloons reached altitudes of about 130,000 feet.

The cosmic ray instrumentation consisted of a cosmic ray heavy primary telescope, linear amplifiers, pulse storage circuits, a 512 channel pulse height analyzer, track position circuits, calibration unit, associated logic circuits, power supplies, and a temperature sensor. AFCRL was asked to make cosmic measurements because of its long and unique experience in cosmic ray research. AFCRL cosmic ray experiments have been flown in scores of sounding rockets, balloons and satellites over the past several years.

The Labrador balloon flights will permit AFCRL and NASA personnel to compare the flux of cosmic rays in high latitude regions with results of a somewhat similar AFCRL-NASA experiment conducted in Minnesota in the summer of 1960. Dr. Herman Yagoda of AFCRL together with those of other partici-

pating agencies have recently prepared a report of results of the earlier tests.

The Minnesota study was undertaken to determine whether the brains of mice flown in the stratosphere are damaged by cosmic rays. In these tests four balloon flights were made carrying a total of 36 mice. Altitudes were maintained between 130,000 and 140,000 feet for 10 to 12 hours. The capsules in which the mice were flown were thin fiber glass spheres of 24 inch diameter. Each mouse was housed in a separate compartment with its head held stationary.

As in the Labrador tests, it was necessary to determine the energy, flux and direction of the cosmic rays to which the mice were subjected. Unlike the more elaborately instrumented tests in Labrador, the Minnesota tests relied primarily on photographic emulsion blocks for cosmic ray detection. High energy particles passing through such blocks leave a track. When the incoming particle strikes a particle within the block, a "star" is produced. The energy of the incoming particle is determined by the number of prongs produced by the nuclear event. Higher energy particles, of course, produce a greater number of prongs. The direction of the ionizing particles can be deduced from their track through several layers of emulsion, which are arranged in a predetermined configuration.

The head of each animal was maintained in a fixed position so that its center point was known relative to the fixed edges of the emulsion block. Thus it was possible to determine the number of particles reaching the brains of the animals.

Following a long and thorough analysis of the tests, it was found that star-production on each of the flights varied between 1581 and 2111 per cubic centimeter per day. The animals were sacrificed over periods of three to 66 days after the flights. Each of the 36 brains examined received an average of about seven hits. Intensive examination of the brains microscopically yielded no evidence of damage attributable to cosmic rays. AFCRL's role in the project was solely concerned with detection and analysis of the cosmic rays. It is expected that the Labrador tests will show a greater rate of cosmic ray penetration.

# HAIL STORMS as EFFICIENT RADAR TARGETS

Meteorological Research Laboratory and Electromagnetic Radiation Laboratory (AFCRL)

Hail storms produce exceedingly strong radar reflections. Recent experiments conducted at AFCRL have provided an explanation for the extremely large radar returns associated with hail storms. In these experiments plexiglass spheres of varying refractive indices were used to simulate hail. One notable result of the experiment was that a 7.2 cm plexiglass sphere was found to have a cross section 2 db larger than the same size Luneberg lens, which is theoretically the perfect focusing device.

The research grew out of earlier work by Dr. David Atlas of AFCRL, who during his year as a NSF Post-Doctoral Research Fellow at Imperial College, University of London, conducted experiments to measure backscatter from artificial hailstones. He found that a dry sphere of ice larger than about two wavelengths in diameter scattered much more efficiently than a metal sphere of equal size. It was tentatively suggested that this odd result was due to the reflection and focusing of energy from the back surface of the ice. Since his return to AFCRL, Atlas has been conducting studies to confirm this suggestion.

For spheres of refractive index between 1.4 and 2 one finds, by geometric optics, that there is a ray which comes to a perfect focus at the rear pole of the sphere and returns to the radar from the conjugate point on the circle of incidence. In fact, all rays incident along this circle are returned to the radar. If one then places a metal cap at the rear pole, the radar cross section should then be enhanced by a predictable amount.

Experiments were conducted with a 7.2 cm plexiglass ball using the AFCRL 3.2 cm backscatter range at Ipswich, Mass. Without the metal cap this sphere (refractive index 1.61 as opposed to 1.78 for ice) had a cross section 10 db larger than the same size metal ball. Adding the metal cap enhances the radar cross section an additional 8 db in comparison to a predicted enhancement of 7.5 db. This confirmed the earlier suggestion of reflection from the back surface of the sphere.

In a sense, each sphere acts as a Luneberg lens. A Luneberg lens is designed so that all the incident energy is focused toward a

rear pole cap and reflected along reciprocal paths to the radar. Reasoning from theoretically calculated backscatter cross sections for a reflective index of 1.78 (ice), it is shown that such a sphere will be equal or slightly superior to a theoretical Luneberg lens for all diameters up to 6.4 wavelengths, where its gain is about 400. A practical Luneberg lens is even worse. Thus at 3 cm wavelengths it is hardly worth using a Luneberg lens smaller than a foot in diameter. The simplicity of producing a sphere of constant refractive index as compared to the fabrication of a Luneberg lens with adjacent shells of increasing index toward the center, makes these targets quite economical, and suggests the idea of using the spheres as antennas.

The experiments were carried out by Sheppard Holt of AFCRL who measured spheres and spheroids of several indices. The results also lead to the suggestion that the general size of hail may be determined if multifrequency radar observations of hail storms are made.

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